

GUJARAT TECHNOLOGICAL UNIVERSITY

BIO MEDICAL ENGINEERING (31)

BIOSENSORS & BIOMEMS

SUBJECT CODE: 2713102

SEMESTER: I

Type of course: Major Elective

Prerequisite: Fundamentals of Transducers, Fundamentals of Biomedical Instrumentation System

Rationale: This subject covers the fundamentals of various types of biosensors & BioMEMS and help Post Graduate students to understand modern biological sensor principles and fabrication technology. Another important objective is to provide the student with the ability to design new sensors, based on application of “smart” biomaterials. . The understanding of these principles is crucial to the evaluation of commercial systems/products as well as the development of new biosensors for emerging healthcare applications in the twenty-first century

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
					ESE	OEP	PA	RP		
3	2	2	5	70	30	20	10	20	0	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	General principles, Definition & Concepts: Generalized Instrumentation System, General properties of input transducer, Static and dynamic characteristics, Primary and secondary transducer, Active and passive transducer Signal transduction; Physio-chemical and biological transducers; Sensor types and technologies.	3	5
2	Physico-chemical transducers: Electrochemical transducers (amperometric, potentiometric, conductometric); Semiconductor transducers(ISFET,ENFET); Optical transducers (absorption, fluorescence, bio/chemiluminescence, SPR); Thermal transducers; Piezoelectric and acoustic-wave transducers; Limitations & problems to be addressed; An Overview of Performance and Applications	6	15
3	Bio sensors: Catalytic biosensors: mono enzyme electrodes; bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes; Affinity-based biosensors; Inhibition based biosensors; Cell-based biosensors; Biochips and biosensor arrays; Problems and limitations.	5	15
4	Biosensor for physical measurands & their measurement: Displacement: Capacitive: parallel plate and cylindrical plate transducer, Types (Change in area of plates, change in distance between plates, variation of dielectric constant) ,Variable resistance transducer, Variable inductance transducer, Differential transformer transducer, Variable capacitance transducers, Electro dynamic & magnetostrictive transducers, Force balance, transducers, Pressure measurement,	8	20

	Radiation: Photo sensors, IR Sensors, Force Measurement, Torque Measurement, Flow: Vortex Shedding Flow meters		
5	Application of modern sensor technologies: Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; Drug development and detection; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations.	4	10
6	BioMEMs:Materials & Fabrication: Typical MEMs and Microsystems, materials for MEMS - active substrate materials- Silicon and its compounds, Silicon piezo resistors, Gallium Arsenide, quartz, polymers. Micro machining photolithography, thin film deposition, doping, etching, bulk machining, wafer bonding, LIGA	4	10
7	MECHANICAL AND THERMAL SENSORS AND ACTUATORS Mechanics for MEMs design- static bending of thin plates, mechanical vibration, thermo mechanics, fracture and thin film mechanics. Mechanical sensors and actuators – beam and cantilever – microplates, strain, pressure and flow measurements, Thermal sensors and actuators- actuator based on thermal expansion, thermal couples, thermal resistor, Shape memory alloys- Inertia sensor, flow sensor	4	10
8	APPLICATIONS OF MEMS IN MEDICINE CAD for MEMs, Biological MEMS materials, polymer based gas sensor, micro total analysis systems (MicroTAS) detection and measurement methods, microsystem approaches to polymerase chain reaction (PCR),DNA sensor, Drug delivery- Types of reservoirs, Case study: Design of BP sensor, Affymetrix DNA microarrays, Cholesterol Monitoring, Implantable Glucose Monitoring Device	6	15

Reference Books:

1. Introduction to Bio analytical Sensors, John Wiley & Sons, 1998.
2. Electrical Measurements and measuring Instruments by A. K. Sawhney
3. Biomedical Transducers and Instruments by Tatsuo Togawa, Toshiyo Tamura, P. Ake Oberg
4. Biosensors- An Introduction by Brian Eggins
5. Steven S. Saliterman “Fundamentals of BioMEMS and Medical Microdevices,” SPIE Press, Jan 2006
6. Sensors in Biomedical applications - fundamentals, technology and applications Gabor Harsanyi, ISBN: 1-56676-885-3 CRC Press; 2000
7. Biosensors and Their Applications, Yang, Victor C.; Ngo, That T. (Eds.) ISBN: 978-0-306-46087-6 Hardcover, 368 pages 2000

Course Outcome:

1. Describe the working principles of biosensors in terms of their bio recognition elements and signal transduction schemes (e.g., optical, electrochemical/electrical, and mass-sensitive);
2. Evaluate the performance of biosensors (e.g., sensitivity and selectivity) and critically compare different commercial devices;
3. Apply the fundamental principles to design novel biosensors for biomedical applications;
4. Appreciate the importance of biosensors in biomedical engineering/medical laboratory science and identify future opportunities/directions.
5. It covers the basics of MEMS and biomedical micro devices together with the application areas. They are able to describe standard micro fabrication techniques used in the construction of

biomedical microsystems & major classes, components, and applications of biomedical microsystems as well as the fundamental operation principles

Suggested List of Experiments:

1. To study about various static and dynamic characteristics of Transducers.
2. To study about Electrochemical & optical Transduction.
3. Introduction to various types of Biosensors.
4. To study about different types of Force Measurement Techniques.
5. To study about different types of Torque Measurement Techniques.
6. Introduction to BioMEMs.
7. To study about various fabrication techniques of BioMEMs.

Suggested Open Ended Problems:

- BioMEMS: Revolution in drug delivery and analytical techniques
- From MEMS to Bio-MEMS and Bio-NEMS: Manufacturing Techniques and Applications
- POLYMER BioMEMS for Implantable Drug delivery.
- Biosensor Microchip